FLOSS Participants' Perceptions about Gender and Inclusiveness: A Survey

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***Abstract*—Background: While FLOSS projects espouse openness and acceptance for all, in practice, female contributors often face discriminatory barriers to contribution. Aims: In this paper, we examine the extent to which these problems still exist. We also study male and female contributors' perceptions of other contributors. Method: We surveyed participants from 15 FLOSS projects, asking a series of open-ended, closed-ended, and behavioral scale questions to gather information about the issue of gender in FLOSS projects. Results: Though many of those we surveyed expressed a positive sentiment towards females who participate in FLOSS projects, some were still strongly against their inclusion. Often, the respondents who were against inclusiveness also believed their own sentiments were the prevailing belief in the community, contrary to our findings. Others did not see the purpose of attempting to be inclusive, expressing the sentiment that a discussion of gender has no place in FLOSS. Conclusions: FLOSS projects have started to move forwards in terms of gender acceptance. However, there is still a need for more progress in the inclusion of gender-diverse contributors.**

***Index Terms*—FLOSS, Open Source, gender, survey**

I. Introduction

Free/Libre and Open Source Software (FLOSS) projects are known for being open and free. Anyone from anywhere can contribute. However, despite this apparent openness to all, FLOSS projects have a severe shortage of female contributors. On average, only 1-5% of FLOSS contributors are females. Compared with approximately 25% of computer science professionals who are female [6], [25], this number is dismally low. Because FLOSS projects can greatly benefit from the diversity of female contributors and from potential new contributors, it is crucial to better understand the sources of the problem and find ways to improve it [4].

To better understand the perception of gender in FLOSS projects, we conducted a survey of contributors from large FLOSS projects. While a number of previous papers have studied the interactions between genders in FLOSS (see Section II for more details), this paper describes both male and female impressions of gender interactions in FLOSS. This perspective allows us to identify how both males and females view gender diversity. The results should inform future attempts to make FLOSS projects more open to female contributors by revealing the biases and problems extracted from both male and female FLOSS participants.

The primary contributions of this paper include (1) an investigation of both the male and the female perspectives on gender relations in FLOSS, (2) how contributors perceive projectmates of another gender, and (3) how males and females interact in FLOSS. In addition to these main contributions, the paper also identifies areas for improvement.

The paper is organized as follows: In Section 2, we define the research questions. In Section 3, we explain our survey methodology. In Section 4, we present the survey respondents' demographics. In Section 5, we describe the survey results and discuss their implications. In Section 6, we discuss Threats to Validity. Finally, in Section 7 we conclude the paper.

II. Research Questions

In this section, we describe the research questions that drive this study, motivating each with a review of the literature.

A. FLOSS Contributors' Experiences

To determine whether the experiences of male and female FLOSS contributors differ, we must first examine the overall experiences of FLOSS contributors. Here we examine some general aspects of contribution. First, we need to understand what motivates FLOSS contributors and what barriers they face during contribution (topics we have explored more generally in our previous works [11], [12]). This information will provide insight into whether the experiences of the contributors differ based upon their gender.

Second, because FLOSS contributors can contribute anonymously, if they wish, we explore whether they hide their gender behind pseudonyms. While this concept of relying on anonymity was one of the original claims of FLOSS, other research has shown that simply relying on anonymity to provide a non-sexist environment is a naive approach which does not work in practice [16]. A study by Vasilescu et al. found almost half of project members thought they could identify the genders of almost all contributors, even those who used pseudonyms [26]. As anonymity is not a sufficient method for obscuring contributors' genders, we must consider gender as a feature of contributors' interactions in FLOSS.

Based upon these characteristics, we can create a picture of contributor experience. This picture will enable observation

of differences between male and female FLOSS contributors. Therefore, the first research question is:

> *RQ1: What are the experiences of FLOSS contributors?*

B. Perception of Female FLOSS Participants

Gender has long been a topic of interest in FLOSS, as it has been in computer science in general. Even though 24.5% of software engineers employed in 2017 were female [6], only 1-5% of open source developers are female [7], [25]. This gap between the frequency of employed, capable female software engineers and the frequency of female software engineers who participate in FLOSS projects suggests that female software engineers are largely excluded from or otherwise persuaded against contributing to FLOSS. Because diversity can improve a project through new perspectives and ideas [4], [26], this low representation of female FLOSS participants is detrimental to the FLOSS movement.

Despite this inequity, male FLOSS contributors often downplay the lack of females as a "non-problem" or by suggesting that females simply do not want to contribute [25]. The line of reasoning goes as follows: if anyone can contribute to FLOSS, then there must be fewer women because women choose not to contribute. However, this line of reasoning uses the very concepts of freedom and openness that are meant to be inclusive to all as a way to dismiss the validity of the concerns of the marginalized group [19].

Perhaps this way of thinking is because, to a certain group of male contributors, the absence of women poses fewer problems than actually changing the culture so that it is inclusive towards women [16]. Many FLOSS participants parrot a common refrain that acknowledging gender is pointless, as gender is not necessarily expressed in semi-anonymous FLOSS communities. However, as gender can become a serious issue for a female newcomer who attempts to join a project, it is necessary to acknowledge the problem before we can attempt to assuage the issues that arise from gender-bias [16], [24].

Contrary to what many male FLOSS participants think, the culture of FLOSS projects is very unfriendly towards females [26]. As Nafus described, "sexism [in FLOSS projects] is as constant as it is extreme" [16]. In a survey by Powell et al., approximately 50% of female contributors had witnessed and/or been subjected to gender-based online discrimination. These respondents also reported negative emotions of feeling alienated and outnumbered by their male peers [17]. Other barriers to female participation include a lack of female mentors, perspectives, and role models, mysogynistic fellow project members, and a highly-masculinized, aggressive method of discourse through which contributors defend their code [19].

As most FLOSS projects are male-dominated, it is not surprising that a project's 'acceptable barriers' are often strongly influenced by the male perspective. For example, most FLOSS communities expect contributors to start off being able to code at the project's standard level. This expectation is male-oriented compared with the more female-oriented view of lowering entry barriers so that newcomers can learn how to contribute. Dreamwidth, a female-dominated FLOSS project, lowered entry barriers by providing an environment that showed politeness towards newcomers. This approach attracted more females [15]. This type of practical politeness attracts and retains more female participants as opposed to the harsher, higher expectations that come from the male-oriented attitudes [5], [8] often pervasive in FLOSS projects.

Previous work has examined females' perceptions of contributing to FLOSS and the barriers and biases they face. In this study, we examine these issues from both the male and female perspective to determine whether male contributors are aware of the struggles their female counterparts face in such a male-dominated environment.

This highly masculine culture and the difference in female-dominated projects leads us to ask:

> *RQ2: How are females contributors perceived in FLOSS? Are all contributors aware of the biases, barriers, or sexism female contributors may have to face that male contributors do not?*

C. FLOSS Contributors' Interactions with Contributors of the Opposite Gender

FLOSS contributors' perceptions of contributors from the opposite gender can influence their interactions. Kofink et al. showed one dramatic illustration of this perception problem in which female contributors on GitHub who chose to identify their gender were more likely to have their code rejected when contributing to a new project [24]. However, those female contributors who were familiar with the projects were slightly more likely to have their code accepted than male contributors, whether or not they revealed their gender [9], [24].

This situation may result, to some extent, from to the 'impostor syndrome' many female computer scientists feel. In this syndrome, being capable computer scientists, females consider themselves frauds, an opinion that may be shared by male contributors [18], [26]. Someone who believes that they are not a 'true' computer scientist may put more effort into a patch, to ensure that the other contributors cannot tell that they are 'faking' it. These biases, among others, can strongly influence interactions. By examining interactions with the opposite gender, we can discover any biases, stereotypes, or other aggression that might be prevalent in average discussions.

> *RQ3: How do contributors interact with contributors from the opposite gender?*

D. Traditional Gender Roles

Regardless of whether they chose to contribute anonymously, females contributors are expected to masculinize themselves to fit in with FLOSS projects, rather than be allowed to express their femininity [17]. As FLOSS projects

are male-dominated, the masculine becomes the 'normal' and the feminine is seen as 'abnormal.' If female contributors do express their femininity, they may be treated as a romantic interest or as a mother figure rather than as an equal contributor in the project [16]. Therefore, we ask:

> *RQ4: Are female contributors expected to conform to gender-based stereotypes?*

E. Perception of Women as Software Engineers

Gender biases against females in computer science are pervasive and start early. In Western countries, females are much less likely to major in computer science. Those who do major in computer science tend to view themselves as the minority, a view often shared by fellow students [18]. In a study of success factors in computer science courses, Wilson found that differences between genders were significant only when the participants already had a significantly different self-perception of their math ability. Wilson also found *comfort* predicted female success [27]. These results suggest that the belief that comfort with the FLOSS community is not a factor in continuing to contribute or in leaving is incorrect.

If culture, society, and the FLOSS community have already told female participants they are less capable in math, then they are less likely to succeed at computer science, and vice versa. This gender-bias is not true in all societies. For example, in Malaysia, females are expected to do better in "indoor activities" such as studying and math. As a result, the majority of computer scientists in Malaysia are female [13].

By examining contributor attitudes towards female and male contributors, we attempt to discover whether there is a difference in the perception of male and female software engineering skill levels. Therefore, we ask:

> *RQ5: Are females contributors perceived to be less skilled software engineers?*

III. Methodology

To answer these research questions, we developed the survey described in this section.

A. Population

We began by identifying 15 FLOSS projects. Due to their size and maturity, these projects were likely to have female contributors and participants who had interacted with participants of a different gender. All of these projects also required code review, using Gerrit, prior to merging new code. The use of Gerrit increased the chance project members had interacted.

Using a Java script similar to the one used in previous papers [12], we extracted the email addresses of contributors who had either requested or performed a code review through Gerrit. We performed the data extraction in mid-March 2018 using as much of the project history as possible. In some cases, poorly formatted information prematurely stopped the extraction process. To ensure completeness, we combined the results from the new mining process and the results from a previous mining exercise in 2015 [2]. This process resulted in 10,864 email addresses of which 8,223 were unique.

We emailed each participant a personalized survey invitation that specified the FLOSS project for which we identified their participation. We also offered respondents a chance to enter a drawing for an Amazon gift card after completing the survey. Of the 8,223 survey invitations sent, 1,100 bounced leaving approximately 7,200 valid email addresses. Because we extracted data from the entire project histories, we could not know how many of those 7,200 email addresses were still valid and being monitored by recipients. We received 119 completed surveys (out of 307 who began the survey). Of those that completed the survey, 103 respondents were male, 13 were female, and 3 chose not to report their gender. While the number of female responses is low, our rate of 10.9% of respondents being female is much higher than the typical 1-5% proportion of females in FLOSS [7].

To increase the participation of females in the survey, we repeated the survey with an additional pool of respondents. For the second iteration, we attempted to send the survey only to FLOSS participants that we had reason to expect were female. We extracted email addresses from another set of projects, using the same approach as the first survey. Similarly, these emails were taken from Gerrit-using projects. We filtered the emails with a gender-identifying algorithm to select only female contributors, as according to the algorithm [23]. Of the resulting 3,343 email addresses, 728 emails bounced, leaving 2,615 valid email addresses. We received 171 completed surveys. Of those, 47, or 27.5%, were female. An additional 7, or 4%, chose not to specify their gender.

B. Survey Design

Based on the research questions defined in Section II, the survey contained a series of open-ended, closed-ended, and behavioral scale questions on the role of gender in FLOSS projects. The gender perceptions questions from the survey are based off of ones found in [1]. Figure 1 contains a list of these questions. In addition, the survey also contained demographic questions (not shown due to space).

We made a few slight modifications to the survey for this second round. We removed Q6 because it was not providing useful information and to increase anonymity. We added Q33 and Q34 on sexism to better understand this phenomenon and augment questions already on the survey.

C. Data Analysis Process

For the qualitative data, both authors coded all responses. Each author coded the responses separately. We began by coding all questions in the first 20 responses. Each author developed their own set of codes. The authors met to agree upon a set of codes based on the ones they independently developed. We then repeated this process with the next 50 responses. Finally, we repeated the process with the remainder of the responses. Both authors coded all questions individually

Fig. 1. Survey Questions

Note that in the first survey, the questions included the project's name where appropriate.

Open-Ended Questions

- Q1 Do you use a pseudonym that is neutral- or a different gender than your own? If yes, why?
- Q2 Do you feel that you interact differently with someone of your own gender than with someone of a different gender? If so, explain the differences.
- Q3 Do you feel that someone of your own gender interacts differently with you than someone of a different gender? If so, explain the differences.
- Q4 Have you ever observed sexist behavior in FLOSS? If so, what was it? How was it resolved?
- Q5 What is the biggest barrier you face, or have faced in the past, with contributing to FLOSS? Explain.
- Q6 Please explain how your project is representative or not.

Behavioral Scale Questions

Indicate to what extent you agree with each of statement using the following scale:
[Strongly Agree, Agree, Somewhat Agree, Neither agree nor disagree, Somewhat disagree, Disagree, Strongly Disagree]

Gender-Perception

- Q7 When I look at reviews of my code, I read the usernames first to determine the gender of the reviewer.
- Q8 When I look at code I'm reviewing, I first look at the username to determine the contributor's gender.
- Q9 In general, male participants are more knowledgeable about code than female.
- Q10 I am more careful when discussing things with female participants, because their feelings are more easily hurt.
- Q11 I think that women are emotionally weaker than men.
- Q12 Women rely more on instinct than reason when it comes to discussing code.
- Q13 Men are naturally better at coding.
- Q14 It bothers me more when a woman is pushy about something in the code than when a man is pushy.
- Q15 Men should have the final say in any decision about the project.
- Q16 I see nothing wrong with contributors approaching other contributors for romantic reasons rather than project-based reasons.
- Q17 It bothers me when I see a developer asking a female participant for personal details, or who is more interested in her life rather than her coding.
- Q18 I would be just as willing to work on a project with female admins/board members as one without any females.
- Q19 I am equally careful with how I word things when I speak to male and female participants.
- Q20 I dislike it when women are treated as sexual objects instead of fellow contributors.
- Q21 I think that a female developer can code as well as a male developer.
- Q22 Female participants should be prepared to oppose male participants to be treated equally in the project.
- Q23 I like seeing female developers be aggressive about defending their code.
- Q24 Male developers use instinct rather than reason as much as women when it comes to discussing code.

Gender Roles

- Q25 Other members of the project see me as a parental figure.
- Q26 I have been asked for unsolicited dates or been flirted with against my desires.
- Q27 Other members have made inappropriate advances.
- Q28 I am expected to take care of other members of the project more so than is usual.

Ability to Contribute

- Q29 I have an equal chance to get code accepted.
- Q30 Nothing keeps me from contributing to the project.
- Q31 I have a solid network of open source peers.
- Q32 It was easy to find a mentor with whom I felt comfortable.

Sexism *(asked to those who identified as non-male only)*

- Q33 Do you think it is difficult to get your code accepted as a female developer?
- Q34 Have you personally experienced sexist behavior? If so, could you describe it or give an example?

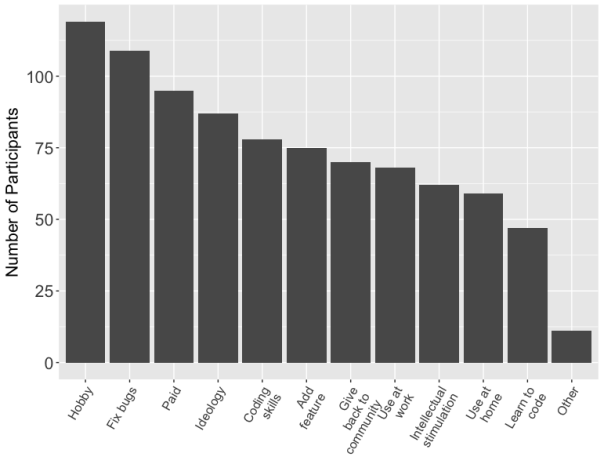

Fig. 2. Motivations for Contributing to FLOSS

before they met to compare codes. In all cases, both authors came to agreement upon the final coding after discussion. We repeated this process for analyzing the second survey, with the only difference being that we started with the codes from the first survey and added new codes only when necessary. We analyzed the quantitative using SPSS and Microsoft Excel. Due to the low number of female respondents, it was not possible to compute inter-group statistics like the $\tilde{\chi}^2$ test. In the results section, we report a qualitative discussion of the differences between the responses of males and females.

IV. Demographics

This section characterizes the sample based upon a number of common demographics. While we do not attempt to analyze the responses based upon these subgroups, we use these characteristics to show that the sample is generally representative of what one would expect to find in FLOSS projects.

In terms of effort devoted to the project, the respondents spent an average of 44.7 hours/month on their respective FLOSS projects. Of that time, they spent half writing code and half in other activities like chats, discussions, mailing lists, documentation, code review, and other. Therefore, the respondents are contributors who spend a significant amount of effort contributing code.

Figure 2 illustrates the varied motivations respondents gave for why they contribute to FLOSS projects. The most common motivation was *hobby*, i.e. those who enjoyed coding and contributing to FLOSS without being paid. This intrinsic motivation is also most commonly found in long-term contributors [10], [20], [21]. Based on this result and the other common motivations given, we can conclude that the respondents are people who are committed FLOSS contributors.

Because the respondents' projects all employed code review, we analyzed the respondents' perception of code reviews. The respondents indicated the reviews of their code were primarily kind (46.3%) or neutral (33%), with only a small percentage being harsh (20.7%). The respondents also indicated the original code authors' responses to their reviews were primarily neutral (49.2%) with a smaller number being kind (36.4%) or harsh (14.5%). These results confirm that respondents did participate in code review and that code reviews were overall not a serious problem for the majority of respondents.

The majority of respondents were young or middle aged. The ages are evenly distributed over those under 45 (17.8% were 18-24; 35.5% were 25-34; 35.3% were 35-44) with fewer over 45 (11.5% were 45-54 and 3.7% were 55 or older). This distribution fits the typical FLOSS project, where the majority of hobbyists are going to be young and tech-savvy.

In terms of educational background, 67.3% had a degree in computer science, with 35.9% of them earning at least a Master's degree. The next largest group were self-taught (14.7%). The respondents were also experienced FLOSS participants. Many contributors had contributed to more than the project from which we discovered their email (75.6% had contributed to 2-10 other projects, and another 11.1% had contributed in more). Many were also experienced FLOSS contributors (65.6% had 2-10 years experience and 25.1% had more than 10 years experience). Thus, the respondents had sufficient knowledge about FLOSS to comment meaningfully about gender perceptions.

Overall, the respondents were well-educated, devoted contributors who had contributed to several FLOSS projects, suggesting the sample is representative of FLOSS participants.

V. Results and Discussion

This section describes the survey results. Along with each result, we discuss the implications of that result.

A. RQ1: What are the experiences of FLOSS contributors?

To answer this question, we examine four specific topics.

1) Pseudonyms: Because FLOSS participants commonly use pseudonyms, we wanted to understand whether the use of pseudonym was at all related to gender. Survey question RQ1 asked respondents to indicate whether they use a pseudonym that is neutral or different gender than their own.

The results showed 70 respondents use gender-neutral pseudonyms and no respondents used an opposite-gendered pseudonym. Of those 70, 22 were female, almost a third of female respondents. Only about a quarter of male respondents used such. All ten respondents who reported using a pseudonym to prevent being judged based on their gender were female. The male respondents who reported using a gender-neutral pseudonym indicated they chose it either for privacy, to be vague, or for a reason unrelated to gender.

These results suggest gender may factor in to the choice of pseudonyms. All those who deliberately tried to mask their gender (by choosing a name to prevent being judged based on their gender) were female respondents.

2) Ability to Contribute: Questions 29-32 are behavioral scale questions to understand whether contributors felt properly equipped to join their project. We scored each question from 1-7 (Strongly Agree to Strongly Disagree) depending upon the answer given. Because each question was of equal value, we took the median of the scores to get an overall

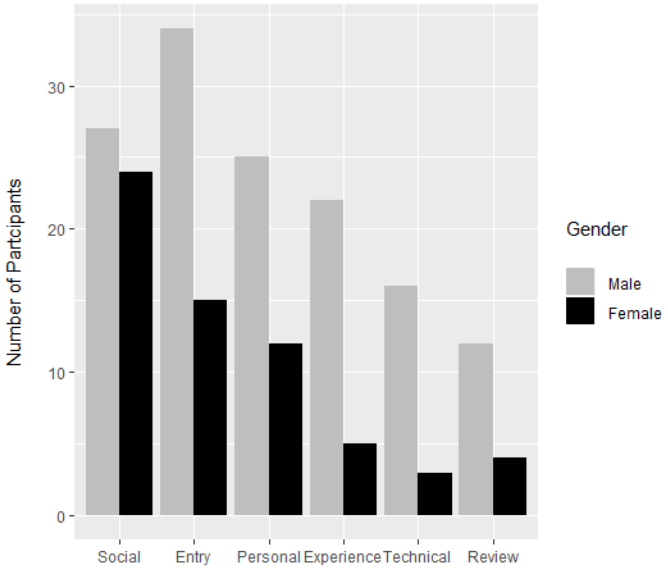

Fig. 3. Barriers to continued FLOSS contributions

sense of the respondents' view of their ability to contribute. The overall median was 2 (*Agree*), indicating no significant hindrances. Overall, neither female or male respondents indicated any of the factors in Q29-Q32 were strong hindrances to their ability to contribute.

3) Barriers: To understand the barriers, Q5 asked respondents to report the biggest barrier they faced. Our analysis of this open-ended question resulted in the six categories in Figure 3. Previous works identified several of these barriers [22]. However, we provide our own interpretation here. *Social barriers* arise from interpersonal relationships (or lack thereof) in FLOSS projects and include responses like "relationships and networking," "hostility," and "lack of mentor." *Entry barriers* are those that a contributor faces when first entering a project and include responses like "build environment," or "complex code." *Personal barriers* relate to or are caused by the contributor themselves and include responses like "lack of time" and "self-confidence." *Experience barriers* arise due to a lack of experience on the contributor's part and include responses like "lack of project knowledge" and "project's programming language." *Technical barriers* are related to technical aspects of the project and include responses like "documentation" or "code submission." Finally, *review barriers* are related to the code review process and include responses such as "difficult reviewers" or "too few reviewers."

Among female respondents, *Social barriers* were most common, with respondents indicating they had trouble being taken seriously, needed to prove themselves, or found it hard to find a mentor or attract attention. Second most common were *Entry difficulties*, including the attitude of other participants and the difficulty of breaking into a close-knit FLOSS community. Third were *Personal barriers*, with respondents indicating they lacked self-confidence, time, or had family responsibilities. In fact, the only respondents to mention family responsibilities as a barrier were female. *Technical barriers* were next most common, including code submission and a lack of documentation.

Among male respondents, *Entry barriers* were the most common. These barriers included the build environment, tooling, corporate difficulties such as license terms, and the attitude of other participants. *Social barriers* were the next most common. Social barriers include relationships, networking, lack of attention, project size, and general communication. In particular, the respondents mentioned issues with "learning how to respon[d] to... comments about code... not taking things personally," and that "teams tend to be very set in doing things their own way, and are often not open to outsiders." In addition, they also found issues with "getting someone to notice [their] patch." *Personal barriers* were the third most common, and included that they lacked time, self confidence, or motivation. Following those were *Experience barriers*, including a lack of expertise, knowledge, or FLOSS experience.

Some barriers were similar between males and females, such as being ignored. The following barriers differed from males to females. Even when the barriers fit into the same general class, such as Social barriers, females tended to report barriers related to difficulties proving themselves while males tended to report barriers related to communication. In particular, entry barriers were very divided by gender. Entry barriers for females are more social (i.e. participant attitudes or breaking into existing communities). Conversely, entry barriers for males were more technical.

Based on these results, it seems that lowering social barriers may be more effective for attracting female participants than lowering technical barriers. However, because females are more risk-adverse [3], they may not even attempt FLOSS contributions if the technical barriers seem too high [14]. Therefore, further study is needed to determine how best to reduce barriers to attract female participants.

Another interesting observation was that females mentioned *expertise* barriers less than *technical* barriers, while males reported the opposite. Prior research has shown that female contributors overprepare for contributing to FLOSS [24]. This result, and the finding that female entry barriers are more social than technical, supports this difference in attitudes towards FLOSS between genders.

B. RQ2: How are female contributors perceived in FLOSS?

We examined whether contributors were aware of the biases, barriers, and sexism female contributors may have to face. For contributors to treat others differently based upon gender, they must be able to tell others apart by gender. Over half of the respondents reported they were able to tell the gender of at least half of the other contributors. This result aligns with an earlier study that found project members tended to be aware of the genders of other contributors [26].

1) Perceptions of females: To understand how respondents perceived female contributors, Q7-25 provided a series of statements for which the respondents could agree or disagree. The goal of these statements was to understand whether gender

perception was positive or negative. Each statement used a 7-point *Strongly Disagree* to *Strongly Agree* scale. To prevent "yea-saying", we worded the first set of statements (7-16) where *Strongly Disagree* represents the most positive gender perception and the second set of statements (17-24) where *Strongly Agree* represents the most positive gender perception. To ease the analysis and the discussion below, we mapped each response to a scale of *Strongly Negative* to *Strongly Positive*. For example, for Q7-16 a *Strongly Disagree* response is equivalent to *Strongly Positive* and for Q17-24 *Strongly Disagree* is equivalent to *Strongly Negative*.

The statements with the most negative sentiment were Q22-24, which had median ratings of *Neither Positive or Negative* and Q16 with a median rating of *Somewhat Positive*. These statements received a more negative sentiment compared to the other statements in the section. One interesting observation is that several of the statements with the most negative sentiment relate to females being aggressive or opposing men.

This result suggests that the attitude of FLOSS participants towards females is improving, as compared to previous studies [16]. Overall, respondents had positive ideas about female contributors. While female participants may have been treated more carefully, something they did not indicate as being desirable, they were generally also given more encouragement. The overall attitude towards female participation in FLOSS can be best summarized as "we need more of them."

Of course, this view is not universal. Some respondents were downright angry about the whole topic. One stated "TOTALLY ANNOYED BY ALL THIS GENDER STUFF" (all caps in the response). Other respondents assured us that no one cares about females or gender diversity in FLOSS projects, e.g. "I think the entire FLOSS community does not give a **** about gender issues/inequality." While this type of response was small relative to the positive or neutral responses, these respondents were usually convinced they were speaking for the project or even FLOSS as a whole. The other responses assured us that this assumption was false. Even so, these strong impressions that FLOSS projects do not care about diversity may stand out to female contributors more than the silent majority that is concerned about diversity and inclusion. This vocal minority may chase away potential female contributors.

2) Sexism in FLOSS: The extent of sexism provides insight into how females are perceived in FLOSS projects. If sexism is as extreme as previous papers claim, then females will be perceived in very a negative light. If sexism is less extreme, then females will be perceived more positively. Q4, Q33, and Q34 helped us examine this aspect.

The majority of the responses to survey Q4 (77.9%) indicated they had not seen sexism in their projects. Those that did observe sexist incidents reported they occurred both online and in person (e.g. meetups or conferences). Of the sexist incidents mentioned in the responses, almost all were directed against women, including offensive comments, unwanted romantic advances, or treating women as though they were incompetent. Only two sexist incidents were against men – an offensive comment against both men and women, and a man who felt that his project's new inclusive policies excluded men.

Only 13% of the incidents resulted in the instigator being punished. None of those incidents were reported by women. Sexism in FLOSS as seen by men may result in in proper punishment. Conversely, sexism in FLOSS as seen by women results in an "ongoing battle," as one contributor described, where no one is punished and the victim may end up blamed. It seems that in FLOSS, men and women have different perceptions of sexism. Men may only be aware of the large, relatively clear-cut incidents that can easily result in punishment. Meanwhile, women have to deal with low-level "normal" day-to-day harassment that can be hard to explain and therefore hard to punish.

Moving from more generic to more personal, when we asked female respondents if they had personally faced sexism in Q34, over one third (38.8%) replied that they had. Interestingly, more respondents replied yes to this question than to the question about sexist incidents in FLOSS in general. This discrepancy suggests that sexist incidents are so prevalent for female contributors that when asked about sexism in general, the female respondents only mentioned the extreme incidents, whereas when questioned about their own experience, they felt more open to mention smaller events. The incidents of sexism experienced by female respondents included sexist statements or assumptions, being ignored, insinuations that they had it easy because they were female, and being simultaneously held to higher standards than men and underestimated.

We also asked female contributors about their ability to get code accepted as a female in Q33. About a fifth (21%) of female respondents felt that it was more difficult to get their code accepted than for their male counterparts. Those who reported it often also reported a frustration with trying to express the difference: "...it's hard to pin down, since they can justify (the) decision in other stuff than gender."

To summarize, both males and females reported seeing incidents of sexism in FLOSS. Almost all of the sexism was against females. The most common types of sexism were men making offensive comments or insinuating that females were nontechnical or otherwise incompetent.

C. RQ3: How do contributors interact with the opposite gender?

To more fully understand participant interactions, we examined both how the respondent treated those of a different gender and how the respondent thought members of a different gender treated them.

1) How respondents interacted with others: Qualitative analysis of Q2 found that 48% of respondents believed they acted differently with someone from another gender. Figure 4 shows a more detailed distribution of responses by indicating both the gender of the respondent and the type of interaction (positive or negative) for those who reported they acted differently. For example, the first column represents male respondents who indicated positive interactions with females, while the third column represents female respondents who reported positive interactions with males.

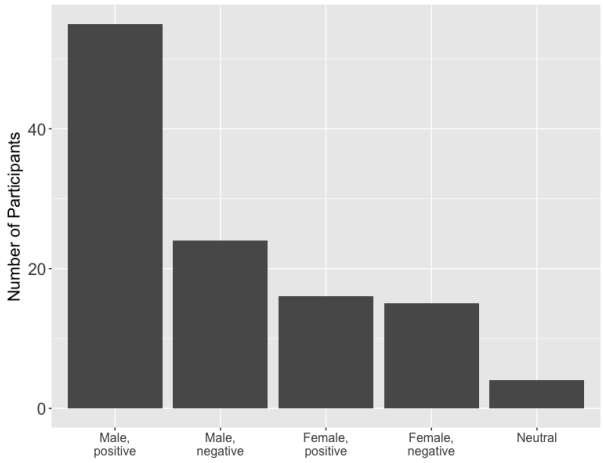

Fig. 4. Respondents' Interactions with Project Members

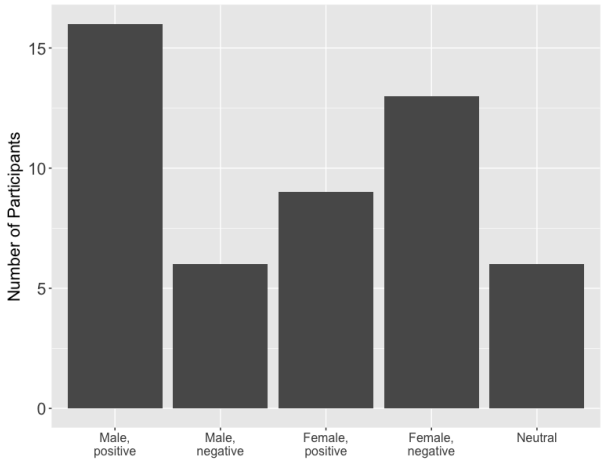

Fig. 5. Other Project Members' Interactions with Respondents

Most male respondents indicated positive interactions with females. These responses indicated that women were friendlier, that they were more encouraging or empathetic with women, or that they were careful or patient with women. While some of these responses play into (positive) gender stereotypes (such as the implication that women are friendlier or that a man has to be careful around a woman), overall, they were positive ideals.

Being careful around women can be either a positive or a negative interaction. The positive interactions included male contributors being more careful around women to "make sure [they were] being fair," to "encourage their participation," and because it is "important to make women feel more welcome in these communities." Conversely, another respondent used this response as an opportunity to complain about female contributors, claiming "I have to be careful not to hurt their egos...given how women empowerment has picked up, I prefer keeping quiet even when I am right." This type of response perpetuates the false stereotype that women are easily offended and that female empowerment injures men.

Conversely, there were a number of males who reported negative interactions with females. Most often, these responses perpetuate negative stereotypes, including women are easily offended, create drama, or even that the respondent has a personal bias against female contributors. For example, one respondent mentioned a fear of women "playing the gender card" and becoming offended over meaningless things. Another respondent claimed that "men are usually more used to being rejected, so there is less potential drama to be afraid of" when talking with men compared to women.

The female respondents reported approximately the same level of positive and negative interactions with males. These positive responses suggested contributors treated men more harshly (positive). The negative responses indicated men require female contributors to prove themselves repeatedly or made them feel less comfortable (negative). Interestingly, the contributors tended to see "being able to treat males more harshly" as a positive, as opposed to the effort of having to take care with their wording around females, which, as seen above, was often cast in a negative light.

The remaining neutral response in Figure 4 indicated that they kept things strictly business with the opposite gender. These responses added that they were more friendly or familiar with their own gender, but were careful not to interact too closely with the opposite gender for fear of appearing romantically interested. Most of these responses were reported by men.

2) How others interacted with respondents: Our qualitative analysis of Q3, found that 51.7% of respondents believed there was no difference in how others of a different gender interacted with them, with 38.1% indicating they believed there was a difference (the rest expressed no opinion). For those that believed there was difference, Figure 5 shows a more detailed distribution of responses. The gender on the column label represents the gender of the respondent. For example, column 1 reports the number of males who believed they interacted positively with females.

Below, we aggregate the reactions into groups. All reactions quoted or listed are representative of the reactions as a whole and encapsulate the common reaction types. Though we may use quotes, all reactions were expressed by more than one person, unless explicitly stated otherwise.

The most common result is positive interactions from males towards the female respondents. The responses indicated females were "more supportive and less likely to be dismissive or rude," were more confidential, more reserved, and worked to create equal footing in conversations. Conversely men "come full force out of nothing, [saying]... 'this is stupid...,' etc." Overall, the responses reported females creating a positive social environment.

The second most common result is negative interactions from males towards female respondents. Negative perceptions of interacting with males included the belief that males were aggressive, relied on gender stereotypes (including the belief

that females are less competent), did not value female input, or would attempt to humiliate female contributors when they interacted with them. As one respondent explained, "other men tend to value my input more than they would women... if I offer a suggestion that a woman has offered, it would be taken more seriously."

Positive interactions from females towards male respondents is the next most common response. These responses indicate men are more friendly with women, more assertive, and given the benefit of the doubt more often than women. The last two traits were considered positive in that women could leverage those traits in allies to make sure their voice was heard.

Finally, negative interactions from females toward male respondents was the least reported result. Negative perceptions of interacting with females included that females were more defensive about their code, stick together, and that interacting with women was unnatural. The neutral responses had to do with the difficulty of separating romance from work, which came from both men and women.

3) Discussion: The majority of respondents did not believe they interacted differently with members of another gender or that members of another gender interacted differently with them. While respondents may not be fully aware of their implicit biases, this result speaks to the ideal of FLOSS, wherein gender is not a factor. Whether or not the respondents truly treat other-gender contributors equally (we can only report individual perceptions), they espoused the ideal that gender is not a factor.

Of those who did admit that their interactions differed, their interactions were largely positive. Even though there were a number of negative interactions, they were outweighed in volume by the positive interactions. However, in practice, it might take only one negative interaction to turn away a potential female newcomer contributor. Because FLOSS is commonly a hobby, people will be less inclined to continue in a hobby where they are negatively stereotyped by their peers.

It is also interesting that the presence of female participants was viewed positively from a social standpoint. Female participants seemed to help create an even footing among contributors and were commonly cited by males and females alike as creating common ground for discussion. Conversely, the male contributors seemed to point more at creating an 'old boy's club' within FLOSS. This result agrees with the results of a previous study that females created a more socially-equivalent community, even in the context of FLOSS [15].

In addition, the negative impressions of male participants focused on their aggressiveness, while the negative impressions of females focused on their defensiveness. Of these two responses, it stands to reason that male aggressiveness, something seen as positive within the male-dominated world of FLOSS, might be lead to female defensiveness. Females form social structures as a preventative measure against aggressiveness [15]. In FLOSS, where such social structures have not been formed and where contributors actively fight their forming, the only relapse is to become defensive. Even in the responses to this survey, we see male participants fighting against the structures females form. Some male respondents complained about having to be careful or polite with female contributors and valued the ability to be harsh toward men. This male-dominant attitude and chain of beliefs may hinder the spreading of positive female influences in FLOSS.

D. RQ4: Are female contributors expected to take on gender-specific roles?

Survey questions Q25-28 focus on whether female contributors were pigeonholed into gender-stereotypical roles and female participants' relative comfort in joining the project. Similar to the other behavioral scale, we took the median of the set of questions. The median was 6, or *Disagree*. When females and males were considered separately, the results were the same. This result indicates that contributors did not feel particularly forced into gender-specific roles.

First, we examine the specific role expectations. For Q25, which asked whether the respondents thought they were viewed as a parental figure, the median was 5 (*Somewhat disagree*) . The female respondents reported the same score as the overall median. The male respondents, however, had a lower median of 4 (Neither agree nor disagree), which indicates more agreement with the statement. For Q28, which asked whether the respondent was expected to take care of other project members, the median was 6 (*Disagree*), which did not differ between males and females.

Second, Q26 asked whether the respondent had been asked for dates or flirted with. The overall median was 7 (*Strongly Disagree*). The median of the male respondents was also 7. The median of the female respondents was 6 (*Disagree*), suggesting that females agreed with the statement more than the overall sample. For Q27, which asked whether project members had made inappropriate advances towards them, the overall median was 7 (*Strongly Disagree*). The median of the male respondents was also 7. The median of the female respondents was 6 (*Disagree*), suggesting that females agreed with the statement more than the overall sample.

Respondents from both genders reported romantic attraction as a reason they might treat the opposite gender differently. When asked about gender roles, respondents were more likely to see female contributors as romantic partners than in other traditional gender roles, e.g. as a mother or a caregiver. Overall, there seems to be more permissibly towards romance in FLOSS projects, which could potentially lead to the harassment of female contributors who only want to contribute and are not interested in romance. Curiously, male contributors may be more likely to feel as though they are in a parental role than the females, perhaps because they served as mentors for new contributors or because they are in positions of power.

E. RQ5: Are females perceived to be worse at coding?

Questions 9, 12, 13, 21, and 24 address this research question. These questions are also part of the overall section on the *perceptions of females* (Section V-B1). We separate them here because of the importance of this particular topic.

First, Q9 made a general statement that males were more knowledgeable about coding than females. The overall median is *Positive* indicating there was not a perception of males being more knowledgeable.

Next, we had pair of statements regarding the use of instinct instead of reason when discussing code. For Q12, which said that females rely more on instinct than on reason, the result was *Negative*, indicating there was not a perception that females used instinct more than reason. For Q24 which said that males rely more on instinct than on reason, the result was *Neither Positive or Negative*.

Last, we had a pair of statements regarding coding ability. For Q13, which said that males were naturally better at coding, the median was *Positive*, indicating there was no perceived difference in natural coding ability. For Q21, which said that females could code as well as males, the result was *Positive*, indicating there was no perceived difference in coding ability.

Only one respondent openly admitted he was biased and believed women were less capable as coders. The majority of respondents, both male and female, view females coders as equally capable contributors. While this can only speak to conscious thoughts rather than unconscious bias, at the very least it indicates that the majority of contributors are not consciously biased against female contributors. However, there was less disagreement with the statement that males use instinct more than reason when coding as opposed to the statement that females use instinct rather than reason, which received a high disagreement score. Perhaps using instinct in coding perceived as positive for males as part of 'hacker culture.' Being able to code by instinct may also suggest that the contributor is capable of doing it without thinking, implying that they are better at coding. If this does indicate that males are perceived to be superior coders, it is odd to have the discrepancy only in this question and not present when asked whether males or females were better at coding.

VI. Threats to Validity

External Validity: The response rate was low (287 responses out of 9,815 non-bounced emails). Therefore, we cannot be certain of the representativeness of the sample. While it would be preferable to obtain a higher response rate, based on past surveys, a low response rate is common when surveying FLOSS projects using this method of recruitment [12].

Internal Validity: Survey respondents may have self-selected based on their interest in the survey topic, as gender in FLOSS is a hot-button issue. It is possible that people with strong feelings on the issue would be more likely to reply to the survey and potentially skew the results. Though a few responses were emotionally charged, most were not. Therefore, although the sample likely had some self-selection bias, the majority of responses did not seem to have overly strong feelings towards the issue of gender diversity in FLOSS.

The respondent pool contained 67 female respondents, even though our second survey specifically targeted females only. This low number is likely due to the low percentage of females in FLOSS projects combined with the low response rate for our survey. However, FLOSS projects typically have only 1-5% female contributors [7], [25]. Our survey responses contain 23.3% females. Therefore, even though the number is small, the percentage is higher than in the average FLOSS project.

There is also a potential that we misinterpreted the qualitative responses. To reduce the changes of misunderstanding, we employed a robust process of independent coding followed by discrepancy reconciliation (as detailed in Section III).

Construct Validity: The survey questions may not have accurately captured our intent. The behavioral scale questions in particular may be vulnerable to this threat. To mitigate this threat, we used an established behavioral scale for sexist behavior as the base for our behavioral scale [1]. In addition, our review of the open-ended responses indicated that the vast majority did answer the question as we intended. Therefore, this threat is low.

VII. Conclusion

Gender diversity in FLOSS has long been an important issue. This survey helps continue the discussion on gender-inclusiveness. With the increasing importance of FLOSS in everyday activities, this discussion can help FLOSS advance

Our results showed largely positive impressions about female FLOSS participants and female software engineers. However, female contributors did face sexism. Many of them had encountered a sexist incident and more had personally been treated with sexism. While the majority of contributors might think well of the female contributors, this does not stop them from facing sexism in their projects.

The results also showed largely positive impressions during interactions between contributors of different genders, regardless of the gender of the respondent. The negative comments may help guide future routes for improving interactions between members of different genders in FLOSS projects, such as reminding contributors not to treat others as stereotypes.

FLOSS projects that wish to retain female contributors should advertise this intention through explicit statements that they welcome female participants and have zero tolerance for behavior contrary to this position. While this action will not prevent the low-level sexism, it can indicate to any male contributors who have strongly-held anti-female beliefs that such actions will not be tolerated in the project.

The ideals of FLOSS started by claiming that gender does not matter, because, in theory, anyone from anywhere can contribute. This ideal is often twisted to be exclusive towards females and even exclusive towards the idea of discussing or addressing the lack of gender diversity in FLOSS. By speaking out against trolls and taking steps to be more inclusive towards female contributors, FLOSS projects can slowly roll back the damage done and find a way to encourage participant from a diverse workforce that can grow their community and improve the impact of their project.

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